Practitioner's Docket No. 35015/001 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Schlosser et al.
Application No.: 09/994,251 Group No.: 2855
Filed: 11/26/2001 Examiner: Jewel Vergie Thompson
For: FLOWMETER FOR THE PRECISION MEASUREMENT OF AN ULTRA-PURE MATERIAL FLOW

Assistant Commissioner for Patents
Washington, D.C. 20231

Rule 132 Affidavit of Gary E. Pawlas

Professional Background, Gary E. Pawlas

Gary Pawlas was granted a Ph.D. in Engineering Science from the U. of Toledo in 1991. He was also granted an M.S. and a B.S. in Mechanical Engineering from the U. of Colorado, Boulder in 1983 and the U. of Cincinnati in 1981, respectively.

After obtaining his Ph.D., Dr. Pawlas was employed for over ten years at Micro Motion, Inc., a leading developer and manufacturer of Coriolis flowmeters located in Boulder, CO. While employed there he served as a Research Engineer for three years, the Director of Research & Development for five years, and the Director of Technology Development, Semiconductor for almost two years.

During this time period, the efforts of Dr. Pawlas and his teams resulted in the first commercial non-metallic Coriolis flow controller, a miniature Coriolis flow controller, a Coriolis pump/flowmeter and other Coriolis flowmeter concepts. These projects resulted in over 40 patent disclosures and 20 filed patents in the area of Coriolis flowmeters.

Introduction

The United States PTO has rejected the above identified patent application entitled "Flowmeter for the Precision Measurement of an Ultra-Pure Material Flow" by citing two previous patents as relevant prior art for the use of plastic materials, especially a plastic called PFA (perfluouro-alkoxy), in Coriolis flowmeters. However, neither of these patents teaches how to overcome the problems inherent in making the high purity Coriolis flowmeter using PFA plastic as described and claimed in the above identified application.

The first cited patent, Tanaka et. al. (USPTO #5,157,975), teaches how to make a Coriolis flowmeter from corrosion and temperature resistant, but very brittle, materials such as glass, ceramics, or hybrid glass-ceramic materials. These meters would not require temperature compensation because of their material properties. This patent never mentions PFA. The only mention of plastics in this patent is to use PTFE as a liner or seal.

The second cited patent, van der Pol (USPTO #6,336,370), teaches how to make straight tube Coriolis flowmeters using a heavy flow tube containing recesses to provide good performance as well as low manufacturing costs. This patent only mentions plastic as a possible material of construction, but in no way addresses the many problems that must be addressed and solved when using a plastic flow tube in Coriolis flowmeters.

Clearly, materials of construction play a critical role in each of these two cited patents as well as the patent application under review. Changing the material of construction of an object is often trivial, especially when the material properties are not critical to the functioning of an object. For example, a rolling pin (used to roll dough or pastry for use in baking) is such an object. The coefficient of thermal expansion, tensile

strength, damping, etc. of the material have little impact on the function of the rolling pin. In this case, a patent on a rolling pin made of a new material should not be allowed.

However, when the material properties play a critical role in the proper functioning of an object, changing the material can result in improper operation or manufacture of the object. A Coriolis flowmeter is an example of an object in which material properties are critical. The coefficient of thermal expansion, fatigue strength, yield strength, modulus of elasticity, and damping coefficient are examples of important material properties in the proper functioning and manufacture of Coriolis flowmeters.

In the following sections of this document, the critical role of material properties in the Tanaka and van der Pol patents will be discussed and contrasted with the role of PFA material properties disclosed in the above identified patent application . It will be shown neither patent teaches one skilled in the art how to solve the problems that arise when using PFA in a flow tube for a Coriolis flowmeter as described and claimed in the above identified patent application.

Simply stating in a patent that a Coriolis flowmeter can be made of PFA does not anticipate or teach the solutions to the problems inherent in making a Coriolis flowmeter of PFA. Therefore, such statements should not be grounds for the rejection of the above identified patent application which does address these problems.

Tanaka Patent Discussion

The Tanaka patent teaches the use of materials like glass and ceramics for Coriolis flowmeter applications requiring corrosion resistance or to be used at high temperature (e.g. 200-800°C). The patent then teaches how to overcome the low bending strength and brittleness inherent in materials such as glass/ceramics by designing pipe couplings that won't break flow tubes made from glass/ceramics.

In contrast, the above identified patent application is aimed directly at providing a non-contaminating Coriolis flow measurement for applications in high purity industries such as the semiconductor or bio-technology. This patent application specifically uses PFA because PFA has low levels of extractable metals, ions, and fluorides.

PFA is manufactured using very clean manufacturing processes specifically for the semiconductor and biotechnology industries. The stringently clean manufacturing processes virtually eliminate the presence of contaminants in the PFA material. In addition, the very stable nature of the PFA fluouro-polymer stops migration of any remaining particles in the material. As a result, PFA does not leach contaminants at a detectable level.

In semiconductor or biotechnology industries, a single unwanted ion leaching from materials containing or measuring critical fluids can contaminate the end product. This can result in hundreds of thousands of dollars of material being scrapped. PFA is the non-metallic material of choice in these industries for minimal leaching of contaminants and was chosen for the Coriolis flowmeter measurement flow tubes specifically for this reason. The Tanaka patent is based on the corrosion resistance of glass/ceramics (at high temperatures) and does not discuss high purity or low contamination applications as a problem nor does it suggest a method for solving this problem.

In regards to breaking glass/ceramic flow tubes, PFA is like most plastics in that it is not brittle at typical temperatures like glass/ceramic materials are. PFA is easy to handle and bends with little force. For example, glass/ceramics are approximately one hundred times stiffer than PFA at room temperature. Hence PFA flow tubes are not in

danger of cracking and thus don't require "resilient couplings" as Tanaka teaches for glass/ceramic flow tubes.

In addition, PFA is a Teflon™ derivative and hence very slippery. Specific means of holding a PFA flow tube are taught in the above identified patent application but were not mentioned in the Tanaka patent.

Finally, since glass/ceramic materials have very low Coefficients of Thermal Expansion (CTE). As mentioned in the Tanaka patent, these materials have CTE's between 51.5×10^{-7} /°C and 0.5×10^{-7}/°C. The flowmeters of the Tanaka invention "enable the measurement of the mass flow rate with high accuracy and without temperature compensation even under markedly varying temperature conditions and at high temperatures."

In contrast, the CTE of PFA (1.5×10^{-4}/°C) is approximately 30-3000 times larger than the CTE of glass/ceramics. Thus, a Coriolis flowmeter made from PFA must be temperature compensated or it will have large measurement errors over small (5-10C) temperature ranges. This requires that temperature measurements be made in a Coriolis flowmeter using PFA flow tubes as disclosed in the above identified patent application. The Tanaka patent claims (see claims 1a, 7a, and 14a) are aimed specifically at materials with extremely low CTE's. Clearly, the Tanaka patent did not anticipate the issue of temperature compensation for plastic flow tubes.

van der Pol Patent Discussion

The van der Pol patent teaches that there are performance and manufacturing advantages to a single straight Coriolis flowmeter over dual straight and dual curved Coriolis flowmeters. However, it also teaches that in the case of a single straight tube

Coriolis flowmeter, "the center of mass does not remain constant and therefore forces which appear are not compensated." Consequently, the Coriolis flow tube oscillations are transmitted to the pipeline and pipeline oscillations are transmitted to the flowmeter and hence adversely affect the flow measurement.

This van der Pol patent then teaches a method for overcoming these performance problems by making the flow tube a "thick-walled" tube that has recesses in the tube. The recesses provide access and space to place devices to detect the Coriolis forces. The van der Pol patent then teaches that the mass that is eliminated by the recesses should be small in relation to the remaining mass in the thick-walled tube. The van der Pol patent then claims that this results in the center of mass of the flow tube remaining qualitatively constant and that it "quantitatively has practically no effect" on the measurement result.

Van der Pol then mentions the thick-walled tube can consist of metal, metal alloy, or plastics, including PFA, PEEK, and PTFE. The patent does not mention the issue of using PFA because of it's high purity or minimal leaching of contaminants. In addition, the van der Pol patent does not teach how to solve any of the problems associated with using plastics for a Coriolis flowmeter such as temperature compensation or holding the "slippery" PFA material.

In fact, van der Pol's suggestion to use plastic in place of metal for the flow tube presents practical manufacturing issues. The van der Pol patent teaches that the amount of mass removed from the flow tube for the recesses needs to be small compared to the mass of the remaining thick-walled tube. To keep the thick-walled flow tube massive but of reasonable size, one would want to use a dense material for the thick-walled flow tube such as a metal like steel. Unfortunately, the density of plastics

are 3-7 times less dense than steel; this means that a plastic thick-walled flow tube would need to be 3-7 times larger to achieve the same effect as a steel tube.

Patent Application Claims Discussion

As mentioned above, I served as the Technology Director of a project to make a Coriolis flowmeter from PFA for over two years. As described in previous sections of this affidavit, neither the Tanaka nor van der Pol patents addressed high purity or non-contaminating applications for Coriolis flowmeters. Thus, neither of these patents would have taught me or my team how to overcome the problems of working with a high purity plastic like PFA. The claims from the above identified patent application are next briefly examined to demonstrate the amount of research and development that was conducted by my group and then disclosed in the above identified patent application to address the issues of using PFA plastic in a Coriolis flowmeter.

The following comments are aimed at Claim 1. The first part of the claim recites a "base". To minimize contamination, as discussed and claimed in the above identified patent application, the preferred embodiment of the invention is for a single flow tube (Claim 2). A single flow tube is an unbalanced structure that can cause unacceptable Coriolis measurement results. Several means of overcoming this unbalance, without affecting the cleanliness and/or non-contaminating properties of a PFA flow tube, are taught by the claim elements as including a base with a mass 100 to 1,000 times that of the flow tube (e.g. claims 13 and 14), a dynamic balancer (e.g. claims 16 and 17) and multiple flow tube/base connection points (e.g. claims 7, 8, and 10) . The effort required to develop these techniques consumed the majority of the development team's effort for the better part of eighteen months. Neither the Tanaka nor van der Pol patent teaches and/or claims the use of or means to implement a single flow tube to minimize material

flow contamination. In addition, the van der Pol patent, which requires a non-uniform flow tube, actually increases the possibility of contamination via manufacturing processes. The reasons for and use of a flow tube material that does not transfer ions to the process material is clearly taught in our above identified application.

Next, the use of a flow tube material with high flexibility and low stiffness like PFA plastic, is clearly claimed and differentiated from stiffer materials like metal or glass used in the prior art of Coriolis flowmeters (amended claim 1). Significant effort was required to identify PFA (as well as the specific grade, manufacturer, etc.) as the best choice as a non-contaminating flow tube material. The issues and solutions to making a Coriolis flowmeter from a low stiffness material like PFA has not been taught in the literature until the above identified patent application. Neither the Tanaka nor van der Pol patents teaches and/or claims either of these items.

Next, claims (claims 7-10) are directed to attaching the flow tube to a base. The above identified patent application teaches a specific adhesive to be used for attaching the PFA flow tube to the base. The choice and use of the adhesive took many man-years of development effort to make a commercially viable technique. Neither the Tanaka nor van der Pol patents teaches and/or claims these techniques.

In a similar manner, the above identified patent application teaches and claims preferred and alternative means for achieving a driver and pickoff with the flow tube. Again, many man-years of effort were required to develop these techniques and are disclosed in the patent application. Neither the Tanaka nor van der Pol patents teaches and/or claims these techniques.

Other claims in the above identified patent application teach and solve significant manufacturing and performance issues with the use of a PFA flow tube. These issues

also required significant expenditure of research and development resources to overcome them. For example, the use of a substantially u-shaped base (e.g. see claim 8, for example) significantly reduces manufacturing and assembly time as well as the product cost. Another example that is taught and claimed (e.g. see claim 15) in the patent application is the issue of heat generation from the driver degrading the Coriolis measurement. This occurs because PFA has such a high coefficient of thermal expansion. The preferred embodiment places the driver above the flow tube. Again, neither the Tanaka nor van der Pol patents teaches and/or claims these techniques.

Summary

Our above identified patent application teaches and claims the use of PFA fluouro-polymer in Coriolis flowmeter applications because of it's high purity and non-leaching flow path. In addition, it also teaches solutions to the problems encountered in using PFA in a Coriolis flowmeter. The material properties of PFA are significantly different than traditional material properties used in Coriolis flowmeters made using metal, glass, or ceramics. Significant research and development effort had to occur to advance the state of Coriolis flowmeter development from the prior art to embody a PFA Coriolis flowmeter.

Our above identified patent application teaches one skilled in the art of Coriolis flowmeters why and how to make the flow tube of a Coriolis flowmeter from PFA. Neither the Tanaka nor van der Pol patents discusses high purity or non-leaching flow paths. Neither teaches any of the problems or solutions to the use of PFA in the flow tube of a Coriolis flowmeter. These patents obviously do not enable one skilled in the art to make a Coriolis flowmeter from PFA plastic without undue experimentation.

These two reference patents contain nothing of value to us in our efforts to design and develop the Coriolis flowmeter disclosed and claimed in the above identified patent application. The two reference patents do not address, either directly or by reference, the many problems that were addressed and solved by us in our development efforts.

Respectfully submitted,

Date: 2/21/03

Gary E Pawlas

Gary E. Pawlas, Ph.D.

Residence:
State of Colorado)
) ss
County of Boulder)

Before me this 21st day of February, 2003, personally appeared Gary E. Pawlas, who is personally known or proved to me on the basis of satisfactory evidence to be the person who acknowledged the foregoing instrument to be his/her free act and deed.

Laura S. Mellblom

Notary Public

My commission expires: 8-16-03

LAURA S. MELLBLOM NOTARY PUBLIC STATE OF COLORADO

My Commission Expires 08/16/2003